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The maximum duration of phonation of /a/ in normal and hoarse voiced children

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Hoarseness seems to be the primary type of voice disorder occurring in school-aged children. Voice experts have suggested measurement of maximum phonation times as a clinical tool for assessing vocal function (Fairbanks, 1940; Westlake and Rutherford, 1961; Irwin, 1965; Boone, 1971). Most of the studies on duration of phonation have used adults as subjects; few investigations have involved children. An apparent need, therefore, existed to investigate duration

of phonation in young children.

Accordingly, the present study was designed to measure and compare the duration of phonation of /a/ produced by children ranging in age from six to ten with normal and hoarse voices. The essential question was:

> Does the length of phonation of /a/ in children remain the same regardless of severity of hoarseness, sex, and/or age?

The results indicated: 1) The three variables of degree of hoarseness, sex, and age collectively affect duration of phonation of /a/; 2) as hoarseness increases, the duration of phonation of /a/ decreases; 3) sex is not a statistically significant factor affecting length of phonation; and 4) as age increases, phonation time also increases.

Analysis of variance showed that only 27.31 per cent of the variance between subjects' phonations of /a/ could be explained by the three variables identified in this study as degree of hoarseness, sex, and age. It was assumed that other factors affecting the variance might include lung capacity, height, weight, motivation, fatigue, intensity, and frequency of the vocal tone.

A statistical formula was presented for predicting length of phonation for children between the ages of six and ten with hoarse and normal voices, as identified by the Jewish Hospital Voice Profile (Wilson, 1971). However, because of wide variability among subjects, this formula has little or no clinical relevance for the practicing speech pathologist. Results suggest that duration of phonation of /a/ may not have the diagnostic significance accorded it by voice experts.

THE MAXIMUM DURATION OF PHONATION OF /a/ IN NORMAL AND HOARSE VOICED CHILDREN

by

JO COOMBS

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INTRODUCTION AND STATEMENT OF PURPOSE

I INTRODUCTION

Hoarseness seems to be the primary type of voice disorder occurring in school-aged children. Estimates of the incidence of hoarseness have varied from 2.0 to 41.6 per cent (Sonninen, 1970). Interest in this voice deviancy has led authors to attempt to define and to measure its degrees of severity (Negus, 1939; Frank, 1940; Harrington, 1950; Irwin, 1965; Baynes, 1966; Isshiki et al., 1966; Wilson, F., 1971, and Wilson, D., 1972). Various descriptions, definitions, and theories about causes of vocal deviations have developed from studies on hoarseness. The primary conclusion upon which most authors agree seems to be that hoarseness is a deviation from normal.

Some voice experts (Fairbanks, 1940; Westlake and Rutherford, 1961; Irwin, 1965; and Boone, 1971) have suggested measurement of maximum phonation times as a clinical tool for assessing vocal function. Most of the studies on duration of phonation have used adults as subjects; few investigations have involved children. Writers in the area of voice disorders do not concur on the length of maximum phonation. An apparent need, therefore, exists for data collection in this area.

II STATEMENT OF PURPOSE

Accordingly, the present study was designed to measure and compare the duration of phonation of /a/ produced by children with normal voices and by children with hoarse voices. The goal was to compare children of various ages (ranging in age from six to ten) to determine whether duration of /a/ varied with age and sex. In addition, children with hoarse voices of varying severity ranging in age from six to ten were compared to determine whether duration of /a/ varies with severity of hoarseness. The essential question was:

> Does length of phonation of /a/ in children remain the same regardless of severity of hoarseness, sex, and/or age?

CHAPTER II

REVIEW OF THE LITERATURE

I HOARSENESS

Hoarseness was chosen as the pathological voice to be studied because many authors have agreed that it is the most common voice disorder of children.

Incidence of Hoarseness

Several investigators have collected data on the incidence of hoarseness. Frank Wilson (1971) found that 6 per cent of the 32,542 pupils enrolled in the elementary and junior high schools in the Special School District of St. Louis County had voice deviations and, of these children, 87 per cent had deviations of the laryngeal cavity primarily involving hoarseness. In his study, Baynes (1966) found that 7.1 per cent of the 1,012 children tested demonstrated chronic hoarseness, with the highest incidence found among first grade subjects. According to Greene (1964), more boys than girls display hoarseness and its incidence appears to be higher in children under ten years of age. Hoarseness diminishes rapidly and considerably as children grow older.

Sonninen (1970) proclaimed that even though hoarseness is common, statistics relative to the disorder are not common and much disagreement exists over available figures. For illustration, he cited

statistics of two contrasting studies. One study by Nadoleczmy in 1926 determined that as many as 41.6 per cent of the school children in Germany had chronic hoarseness; whereas, a study completed in 1952 for the American Speech and Hearing Association's Committee on Children and Youth found only 2 per cent of the children between five and twenty-one years of age had chronic hoarseness. The variance is further illustrated by Greene (1964) who cited a study conducted by Seth and Guthrie in 1953 that reported 40 per cent of the children in Germany had hoarse voices. In addition to other possible reasons, the discrepancies among incidence studies may partially result from the investigators' lack of a universal definition of voice disorders and/or hoarseness.

Definition of Hoarseness

Hoarseness has been defined in a number of ways by various authors. Fisher (1966) described hoarseness as sounding like "strained or gargling" breathiness. Frank (1940) defined it as any alteration in the speaking voice which results in "roughened or rasping" character. Fairbanks (1940) indicated that hoarseness combines the features of breathiness and harshness with all hoarse voices having varying degrees of each and with most voices having periods of predominating harshness or breathiness. An improved definition of a "hoarse voice," according to Van Riper and Irwin (1958), is that it is a voice that is "both husky and harsh." Harrington (1950), Williamson (1945), Van Riper and Irwin (1958), and Murphy (1964) all stated that very low pitch levels are associated with hoarseness. Moore (1971) described

hoarseness as a label which refers to a group of phonatory disorders accompanying upper respiratory disease, while Sonninen (1970) described hoarseness as a general term for voice symptoms which may be caused by any disease or disorder to the larynx. D. Wilson (1972) said that the term "hoarseness" is frequently used for any type of deviation of the laryngeal tone. It, therefore, appears that no author has developed a widely-accepted definition of hoarseness.

Moore (1957) has categorized hoarseness into three types, which he termed dry, wet, and rough. The first parameter, dry, was characterized by breathiness with relatively greater phonatory intensity; the second parameter, wet, was described as being lower in pitch, breathy, and often accompanied by vocal fry; and the third parameter, rough, gives the listener the impression of a two-toned voice.

Baynes (1966) reviewed the literature and found all of the following terms used to define hoarseness: rough (seven times), harsh (seven times), grating (five times), lower in pitch (four times), discordant (four times), breathy (four times), husky (four times), harsh-husky (one time), deep (one time), guttural (one time), and throaty-husky (one time). As a result of his review, Baynes' (1966) own definition of hoarseness was, ". . . a quality of voice that is rough, grating, harsh, and more or less discordant."

Voice authors have attempted to devise objective scales to identify and define hoarseness. Isshiki, Okamura, Tanabe, and Morimoto (1969) adopted one such scale which was termed "Osgood's 'semantic differential'" for measuring hoarseness. Seventeen factors which they felt exemplified hoarseness were selected for inclusion into the scale

with seven degrees of severity of each factor. The scale is presented in Appendix A.

F. Wilson (1971) has developed another scale for judging six parameters of voice production: pitch, degree of openness of the vocal folds, nasality, rate, intensity, and vocal range. It is presented in Appendix B. The profile additionally provides a rating scale for recording the severity of the voice problem. Wilson's scale (1971) appears to be the most useful scale yet devised for judging hoarseness.

Physiology of Phonation

Before the causes of hoarseness are considered, it is necessary to describe the physiology of phonation. Boone (1971) and Zemlin (1968) have described the physiology of phonation in the following manner. The phonatory process begins with the vocal folds approximating within 3 mm. of one another where the rate of vibration is determined by the natural size, mass, and elasticity of the folds. The air emitted from the lungs flows to the level of the approximated folds and blows them apart. The elasticity of the folds and the decreased subglottic air pressure then tend to bring the vocal folds back to their neutral approximated position and the Bernoulli vacuum draws the folds even closer together. The Bernoulli vacuum is caused by an increase in the velocity of the constant air flow as it passes through the constricted glottis. This increased velocity results in decreased air pressure at the level of the folds which pulls the folds closer together. Once the folds are approximated, one vibratory cycle has

been completed and the cycle is repeated.

During normal phonation, the folds are approximated at about the same time the expiratory phase of respiration is initiated. The folds are approximated to within 3 mm. A breathy voice is produced when the expiratory cycle begins before the folds are fully approximated or when they are not sufficiently approximated. A hard glottal attack is due to the vocal folds adducting before expiration begins which results in a sudden burst of phonation. The hoarse voice combines the breathy escape of air and hard glottal attacks which are likely due to the subject attempting to compensate for his phonation difficulties.

In hoarse voices there may be a structural deviancy such as a growth, swelling, or rough edges on the vocal folds which has resulted from misuse or overtensing of the vocal folds. Such deviancy prevents normal approximation of the vocal folds, causing breathiness. In an attempt to overcome breathiness, the speaker may use even more laryngeal tension. This combination of harshness and breathiness results in the acoustical end product of hoarseness.

Causes of Hoarseness

Hoarseness in children is caused by a variety of pathologies. Laryngitis has been mentioned frequently as an etiological factor. Negus (1939) wrote that an important cause of hoarseness in children is chronic laryngitis which may be caused by overuse or misuse of the voice. In addition to chronic laryngitis, he further stated that hoarseness is frequently associated with nasal obstruction or with inflammation of the nose, postnasal space sinus, and/or pharynx.

According to Greene (1964), a mild, chronic laryngitis generally accompanies hoarseness and the folds show signs of being swollen and not completely adducted in the arytenoid region. Darley (1971) reported that laryngitis, low habitual pitch level, hard glottal attack, and inadequate pitch variability cause hoarseness. He further stated that hoarseness might result from ventricular phonation because of the increased intensity and the continual use of low habitual pitch level, which is characteristic of this disorder. Murphy (1964) stated that he ordinarily considers hoarseness as an organic problem with its basic origins rooted in poor phonations during instances of shock, worry, fear, and tension. Fairbanks (1940) attributed hoarseness to acute or chronic laryngeal infections or irritation, infections of the superior respiratory tract, and vocal strain. He stated that functional hoarseness is rare because laryngeal strain leads to organic impairment and organic hoarseness.

Hyperfunction and abuse of the vocal mechanism are often attributed to be the cause of hoarseness. Functional hoarseness was described by Boone (1971) as being caused by too tight or too loose approximation of the vocal folds. Harrington (1950) suggested loud talking and singing as the causes of overexertion of the vocal muscles which leads to hoarseness. He explained that overexertion of the vocal mechanism causes irritation of the delicate tissues so that they become swollen with blood. The presence of this excess blood in the laryngeal muscles causes the vocal cords to become heavy, preventing them from moving easily and normally. When this happens, the voice becomes hoarse and low pitched. Harrington (1950) suggested that

screaming and shouting during play and/or straining while singing beyond safe vocal ranges may be causing hoarseness in children. He also considered sinus infection, hay fever, and allergies to be causes of children's hoarseness.

According to Van Riper and Irwin (1958), many hoarse voices are learned and they may be unlearned through proper voice treatment. They further stated that some hoarse voices of prepubescent children seem to be due to their desire to possess an adult voice and that some children's hoarse voices seem to be due to vocal abuse such as screaming and shouting.

Isshiki, Yanagihara, and Morimoto (1966) disclosed that hoarseness is almost always accompanied by an imperfect closure of the glottis, resulting in incomplete modulation of the flow of air. The incomplete closure of the glottis is not sufficient to produce a hoarse voice by itself; however, when it is paired with a narrow glottis and strenuous respiration, an audible hoarse voice is produced. Margaret Greene (1964) presented two interesting causes of hoarseness in children. She felt that long periods of crying by infants may later result in hoarseness and also that children who yell loudly on the playground often suffer from chronic hoarseness. She stated this is particularly common in children between the ages of five and ten years.

Boone (1971) stated vocal nodules in children are usually accompanied by some dysphonia, characterized by huskiness, low intensity, and frequent throat clearing. These characteristics are usually associated with hoarseness. Frable (1962) reported hoarseness is present

in females during the premenstrual period due to the associated increase in the bulk of the vocal cords.

Baynes (1966) aptly stated there is an abundance of literature concerned with the etiologies of hoarseness in adults, but relatively little information exists concerning hoarseness in children. This seems to be particularly true in the area of duration of phonation which may be of diagnostic importance in hoarseness.

II MAXIMUM PHONATION

A Diagnostic Clinical Instrument

The measurement of the phonation time of the vowel /a/ has often been cited as a clinical tool for distinguishing normal and pathological voices. Boone (1971) stated that by instructing a client to sustain various vowels, such as "ah," one could determine the respiration-phonation aspect of a patient's voice production. F. Wilson (1971) maintained that the length of time an individual can sustain the tone "ah" has a relationship to laryngeal efficiency. Westlake and Rutherford (1961) concurred that having a child sustain phonation for as long as possible yields a measure of laryngeal function. Similarly, Yanagihara, Koike, and von Leden (1966) wrote that the overall function of the voice of any individual could be demonstrated by evaluating the ability to sustain voice production. Arnold (1955) stated "a good criterion for the general quality of the voice is immediately available by determining the phonation time." Fairbanks (1940) noted that phonation time is a good indicator of the efficiency of phonation because vital capacity remains reasonably constant. Irwin (1965) suggested

asking potential clients to phonate "ah" because she felt a production of a satisfactory "ah" when all the cavities were open and relaxed indicated that the client would probably be able to acquire a pleasing voice. Isshiki, Okamura, and Morimoto (1967) believed that when there are no instruments such as the spirometer and pneumotachograph available to measure the air flow rate, the technique of measuring the longest phonation is of clinical value especially when there is incomplete closure of the glottis.

Norms for Maximum Duration of Phonation

Several authors have suggested "norms" for duration of phonation. Van Riper (1963) asserted normal individuals should be able to sustain the vowels /i, ɑ, and u/ for at least fifteen seconds. Ptacek and Sander (1963) reported that Westlake suggested in 1952 that a cerebral palsied child should be able to maintain a sound for a minimum of ten seconds. Westlake and Rutherford, in their 1961 publication, subsequently stated that children with normal voices can easily sustain a tone for twenty seconds or longer after a few trials. Arnold (1955) stated that phonation time varies between twenty and thirty seconds for vowels.

Boone (1971) stated that a prepubescent child can sustain a voiceless sound for about ten seconds. He also stated that the individual with a normal voice will sustain the unvoiced /s/ and the voiced /z/ for the same length of time. However, the individual with vocal pathology will sustain /s/ twice as long as /z/ due to the difficulty in producing phonation for the /z/ sound.

These arbitrary norms, then, range from ten to thirty seconds for normal individuals, which is a considerable range for normality. Such inadequacies in experts' knowledge of maximum phonation times led investigators to research the problem.

Previous Research on Maximum Phonation

Some research of maximum phonation time has been conducted by Yanagihara and Koike (1967). In studying adults, they found a mean of 30.5 seconds for males for sustaining /a/ at a medium pitch level and of 22.5 seconds for women. Ptacek and Sander's (1963) results revealed that the average adult male phonated /a/ produced at a moderate, uncontrolled frequency for 22.6 seconds and that the average adult woman, under the same conditions, phonated for 15.2 seconds.

Many authors have studied the relationship of vital capacity to sustained phonation. Vital capacity has been defined as the maximum amount of air a person can expel from his lungs after a maximum inhalation. Yanagihara and Koike (1967) reported that Scalori in 1932 and Hulse in 1936 found little relationship between vital capacity and phonation. From this time on most studies evaluated sustained phonation independently of vital capacity. In their more recent study, however, Yanagihara and Koike (1967) stated, "There is a significant correlation between the phonation volume (the total volume of air available for maximally sustained phonation) and vital capacity." It appears that the relationship between vital capacity and maximum phonation has not been universally determined.

Ptacek and Sander (1963) studied maximum vowel duration at differing intensities and frequencies of phonation and concluded that group mean measures of maximum phonation length were not significantly affected by intensity changes for the low frequency phonations or for the phonations for which frequency was uncontrolled. These findings contradicted the supposition of Van Riper and Irwin (1958) that,

> . . . other factors being equal, it generally requires greater expenditure of air per unit of time to produce voice of great intensity than to produce voice of moderate intensity.

Yanagihara and Koike (1967) found that phonation time decreased significantly with a rise in pitch such as from a medium to a high pitch.

Ptacek and Sander (1963) also compared smokers with nonsmokers and found that smoking does not reduce phonation time. Additionally, they found that over a period of twelve trials there were no consistent practice or fatigue effects.

Perhaps the most similar study to the present study was conducted by Launer (1971). Her study measured the phonation time of 206 boys and girls ranging in age from seven to eighteen years; pitch and loudness levels were controlled. In addition, she investigated the relationship between the three variables of age, sex, and body size and the length of phonation of the sustained vowels /a/, /i/, and /u/. The results revealed that phonation time increases as age increases. Launer concluded from her data that male children phonate longer than female children. She also noted no significant difference existed between the phonation times of the three vowels. Launer further noted that ". . . given height and weight, age and sex add no independent

information, or, given age and sex, height and weight give no additional information." These variables are overlapping predictors.

The studies cited in the above paragraphs summarize the research that has been reported in the area of maximum phonation. An outstanding feature in the literature is that normative studies have dealt almost entirely with adults. Work has been done by Launer (1971) in determining norms for the duration of phonation in children with normal voices, but the literature is lacking in comparisons of maximum duration of phonation time of children with normal and pathological voices. Such comparisons may have clinical implications for evaluating voice deviancies.

CHAPTER III

METHODS AND PROCEDURES

I METHODS

Subjects

Two groups of subjects provided data for this study. Group I was comprised of 62 subjects at three age levels, 6, 8, and 10 (plus or minus three months at each age level). This group was further divided into 31 (16 girls and 15 boys) experimental subjects who exhibited hoarse voices and 31 (16 girls and 15 boys) control subjects who exhibited normal voices. The experimentals were matched with the controls for age, sex, and school attended.

Group II consisted of 190 subjects, including the 62 subjects of Group I, which included 93 girls and 97 boys. Group II included Group I because hoarseness was measured in degrees of severity rather than as a bipolar judgment of hoarse or not hoarse (as Group I was initially described). Of the total sample (i.e., Group II) 38 subjects exhibited normal voices and 152 exhibited hoarse voices.

All subjects resided in the greater Portland metropolitan area. They were selected by two procedures: 1) speech clinician referral and 2) public school screening. Children with hoarse voices were referred by speech clinicians of Portland School District No. 1 and Parkrose Public School District No. 3. Screening of other classrooms containing appropriately aged children was conducted in Lake Oswego School Dis-

trict No. 7 and screening of a preschool round-up was done in Gresham Elementary District No. 4.

Instrumentation

An Artik tape recorder was used in conjunction with 3M Scotch Brand Magnetic Tapes to record speech samples and phonations of /a/ for all subjects. The tapes were replayed on an Ampex 601 tape recorder in conjunction with an Ampex 601 speaker during the training and evaluating sessions. A Cletimer stopwatch was used to measure the duration of phonations.

The Jewish Hospital Voice Profile, presented in Appendix B, was used to rate the degree of hoarseness of each subject in the study. The profile has a scale for judging six parameters of voice production: pitch, degree of openness of the vocal folds, nasality, rate, intensity, and vocal range. The profile additionally provides a rating scale for recording from "1" to "7" with "1" indicating a barely perceptible problem and "7" indicating a problem which significantly interferes with communication. In addition to the whole numbers, a rater may choose to assign a rating which lies halfway between two whole numbers.

On the lower portion of the voice profile, the "A" scale deals with the open and closed positions of the vocal folds. F. Wilson (1971) explained that "-4" at the extreme left indicates the folds are totally open and there is little, if any, friction produced during communication; "-3" represents the narrowing of the vocal chink and a whispered phonation; "-2" indicates turbulence with some friction; "1"

indicates a normal voice; "+2" represents a voice that has much tension and the production is strained; and "+3" indicates extreme tension with random closure and the production is characteristic of an individual with spastic dysphonia. A rating of "+2/-2" indicates a voice which is tense, strained, and breathy, i.e., a hoarse voice.

Scale "B" deals with "Laryngeal Capacity" or pitch. A rating of "+3" or "-3" indicates that an individual speaks either too high or too low for a listener to determine sexual identification based on voice. A "+2" or "-2" represents a deviation of pitch, noticeable only to a critical listener. A rating of "1" is used for a normally pitched voice.

Scale "C" represents "Resonating Cavity" or nasality. A rating of "-2" represents lack of nasal resonance in the voice during production of sounds normally nasalized. A "1" represents a normal voice, "+2" represents assimilation nasality, "+3" represents nasalization of vowels with a slight nasalization of consonants, and "+4" represents nasalization of all sounds plus frequent nasal distortions on consonant sounds.

II PROCEDURES

Data Collection

Two types of data were collected from the subjects. The first was a voice sample in which each child spoke to the examiners in response to questions and the second was the recording of each subject's last two productions of his maximum duration of phonation of /a/. The instructions for eliciting the maximum duration of phonation

of /a/ are presented in Appendix C. Data were collected by: Robert L. Casteel, Ph.D., Speech Pathologist; Mary E. Gordon, M.S., Speech Pathologist; and this investigator, a student in the graduate program at Portland State University.

Data Measurement

The voice samples were analyzed by this investigator who was trained to use the Jewish Hospital Voice Profile by Robert L. Casteel, Ph.D., and Mary E. Gordon, M.S., voice clinic supervisors at Portland State University. A normal voice was defined as one rated "1" on all scales of the Jewish Hospital Voice Profile, except for the "Severity" scale which was rated "0." A hoarse voice was defined as one rated "+2/-2" on the "A" scale and "1" on the other scales except the "Severity" scale, which was rated in half-step intervals from "1" to "7." There was, therefore, a possibility of fourteen "severity" scores, including "0" which was applicable to normal voices.

A training session for the profile was held, using the Jewish Hospital Voice Profile training tapes and tapings of 190 subjects which were randomly placed on the tape recorder.

It was the goal of the training session to reach interjudge agreement of 90 per cent for two consecutive sets of ten undiscussed samples. Agreement among the judges was considered to have been reached when the judges were within a range of one point on the "Severity" scale and in complete agreement on the other scales of the Jewish Hospital Voice Profile. Initially, ratings of voice samples were discussed after each sample; subsequently, discussions were allowed

only after every ten samples. The criterion of 90 per cent interjudge agreement was met on the tenth and eleventh sets of ten consecutive samples; there was no discussion among the judges during or between the presentation of these two sets.

An outside source, Judy Widen, M.S., Audiologist, recorded the twenty samples from the tenth and eleventh sets of samples and randomly selected ten to be re-presented to the raters after seven days. At this time, the three raters reevaluated the ten samples and intrajudge agreement was determined for each rater. As before, a variability of one point on the severity scale was allowed. This investigator's intrajudge reliability was 100 per cent and intrajudge reliability for each of the other two raters was 90 per cent. At that time, this investigator was considered to be trained.

After completion of ratings on all recordings, the twenty recordings used for determining interjudge reliability were evaluated and this researcher achieved 95 per cent intrajudge reliability. This measurement of reliability was achieved sixteen days after the original training session.

The last two sustained phonations of /a/ produced by each subject were measured from the tape recordings. The duration of phonations was measured to the nearest one-half second, using a stopwatch. A mean time score for each subject was calculated.

Data Analysis

The F test was used to determine the significance of the relationship of the three variables (degree of hoarseness, sex, and age)

collectively, to the duration of phonation of /a/. The data provided by the two groups of subjects were collapsed for statistical analysis and analyzed by using multiple regression techniques. Two-tailed t tests for unrelated measures were used to determine the significance of the relationship of each of the variables (degree of hoarseness, sex, and age) to duration of phonation of /a/.

CHAPTER IV

RESULTS AND DISCUSSION

I RESULTS

The purpose of this investigation was to measure and compare the duration of phonation of /a/ produced by children with normal voices and by children with hoarse voices. The goal was to compare children of various ages (ranging from six to ten) to determine whether duration of /a/ varies with age and sex. In addition, children with hoarse voices of varying severity ranging in age from six to ten were compared to determine whether duration of /a/ varies with severity of hoarseness. The essential question was:

> Does the length of phonation of /a/ in children remain the same regardless of severity of hoarseness, sex, and/or age?

The data were analyzed by using multiple regression techniques. The summary of the statistical analysis appears in Tables I and II. Using the predictive multiple regression formula: $\hat{y} = B_0 X_0 + B_1 X_1 + B_2 X_2 + B_3 X_3 + e$, it is possible to determine $\hat{y}$ when $\hat{y}$ represents the predicted value of /a/ in seconds. This formula may be written as length of phonation = 135.39 + (-7.91)(degree of hoarseness, 0 = 0, 1 = 10, 1.5 = 15, 2 = 20, 2.5 = 25) + 78.37 (sex, 0 for girls and 1 for boys) + 10.85 (age in months).

Tables III and IV provide the predictive duration of phonation of /a/ at six-month intervals for degrees of hoarseness ranging from

TABLE I

ANALYSIS OF VARIANCE FOR THE REGRESSION

Source of Variation	Degrees of freedom	Sum of Squares	Mean Squares	F value
Attributable to regression	3	9301784.02343	3100594.50683	23.29475*
Deviation from regression	186	24757108.05468	133102.71917	
Total	189	34058888.10937		

*.01 Probability level.

TABLE II

DATA ANALYSIS OF THE INDIVIDUAL VARIABLES OF HOARSENESS, SEX, AND AGE

Variance	Mean	Standard deviation	Correlation X vs Y	Regression coefficient	Standard error of regression coefficient	Computed t value
Hoarseness	24.68421	17.71034	-0.28134	-7.91051	1.51035	-5.23752*
Sex	0.51052	0.50120	0.08570	78.36671	53.19712	1.47313
Age	95.30000	16.76887	0.40204	10.85080	1.59119	6.81928**
Dependent	1014.21057	424.50647				
Intercept		135.38577				
Multiple correlation		0.52259				
Standard error of estimate		364.83245				

*.001 Probability level.
**.001 Probability level.

TABLE III

PREDICTIVE TABLE FOR DURATION OF PHONATION OF /a/ AT THREE-MONTH INTERVALS FOR DEGREES OF HOARSENESS RANGING FROM NORMAL TO SEVERE FOR GIRLS

Age in months	Severity of hoarseness													
	0	1	1.5	2	2.5	3	3.5	4	4.5	5	5.5	6	6.5	7
72	9.17	8.37	7.98	7.58	7.19	6.79	6.40	6.00	5.61	5.21	4.82	4.42	4.02	2.28
75	9.49	8.70	8.30	7.91	7.51	7.12	6.72	6.33	5.93	5.54	5.14	4.75	4.35	3.95
78	9.82	9.03	8.63	8.23	7.84	7.44	7.05	6.65	6.26	5.86	5.47	5.07	4.68	4.28
81	10.14	9.35	8.96	8.56	8.16	7.77	7.37	6.98	6.58	6.19	5.79	5.40	5.00	4.61
84	10.47	9.68	9.28	8.89	8.49	8.09	7.70	7.30	6.91	6.51	6.12	5.72	5.33	4.93
87	10.79	10.00	9.61	9.21	8.82	8.42	8.02	7.63	7.23	6.84	6.44	6.05	5.65	5.26
90	11.12	10.33	9.93	9.54	9.14	8.75	8.35	7.95	7.56	7.16	6.77	6.37	5.98	5.58
93	11.44	10.65	10.26	9.86	9.47	9.07	8.68	8.28	7.88	7.49	7.09	6.70	6.30	5.91
96	11.77	10.98	10.58	10.19	9.79	9.40	9.00	8.61	8.21	7.81	7.42	7.02	6.63	6.23
99	12.00	11.30	10.91	10.51	10.12	9.72	9.33	8.93	8.54	8.14	7.74	7.35	6.95	6.56
102	12.42	11.63	11.23	10.84	10.44	10.05	9.65	9.26	8.86	8.47	8.07	7.67	7.28	6.88
105	12.75	11.96	11.56	11.16	10.77	10.37	9.98	9.58	9.19	8.79	8.40	8.00	7.60	7.21
108	13.07	12.28	11.89	11.49	11.09	10.70	10.30	9.91	9.51	9.12	8.72	8.33	7.93	7.53
111	13.40	12.61	12.21	11.82	11.42	11.02	10.63	10.23	9.84	9.44	9.05	8.65	8.26	7.86
114	13.72	12.93	12.54	12.14	11.75	11.35	10.95	10.56	10.16	9.77	9.37	8.97	8.58	8.19
117	13.75	13.26	12.86	12.47	12.07	11.68	11.28	10.88	10.49	10.09	9.70	9.30	8.91	8.51
120	14.37	13.58	13.19	12.79	12.40	12.00	11.61	11.21	10.81	10.42	10.01	9.63	9.23	8.84

TABLE IV

PREDICTIVE TABLE FOR DURATION OF PHONATION OF /a/ AT THREE-MONTH INTERVALS FOR DEGREES OF HOARSENESS RANGING FROM NORMAL TO SEVERE FOR BOYS

Age in months	Severity of hoarseness													
	0	1	1.5	2	2.5	3	3.5	4	4.5	5	5.5	6	6.5	7
72	9.95	9.16	8.76	8.37	7.97	7.58	7.18	6.79	6.39	5.99	5.60	5.20	4.81	4.41
75	10.28	9.48	9.09	8.69	8.30	7.90	7.51	7.11	6.72	6.32	5.92	5.53	5.13	4.74
78	10.60	9.81	9.41	9.02	8.62	8.23	7.83	7.44	7.04	6.65	6.25	5.85	5.46	5.06
81	10.93	10.14	9.74	9.34	8.95	8.55	8.16	7.76	7.37	6.97	6.58	6.18	5.78	5.39
84	11.25	10.46	10.07	9.67	9.27	8.88	8.48	8.09	7.69	7.30	6.90	6.51	6.11	5.71
87	11.58	10.79	10.39	10.00	9.60	9.20	8.81	8.41	8.02	7.62	7.23	6.83	6.44	6.04
90	11.90	11.11	10.72	10.32	9.93	9.53	9.13	8.74	8.34	7.95	7.55	7.16	6.76	6.37
93	12.23	11.44	11.04	10.65	10.25	9.86	9.46	9.06	8.67	8.27	7.88	7.48	7.09	6.69
96	12.54	11.76	11.37	10.97	10.58	10.17	9.79	9.39	8.99	8.60	8.20	7.81	7.41	7.02
99	12.88	12.09	11.69	11.30	10.90	10.51	10.11	9.72	9.32	8.92	8.53	8.13	7.74	7.34
102	13.20	12.41	12.02	11.62	11.25	10.83	10.44	10.04	9.45	9.25	8.85	8.46	8.06	7.67
105	13.53	12.74	12.34	11.95	11.55	11.16	10.76	10.37	9.97	9.58	9.18	8.78	8.39	7.99
108	13.86	13.06	12.67	12.27	11.88	11.48	11.09	10.69	10.30	9.90	9.51	9.11	8.71	8.32
111	14.14	13.39	12.96	12.60	12.20	11.81	11.41	11.02	10.62	10.23	9.83	9.44	9.04	8.64
114	14.51	13.72	13.32	12.92	12.53	12.13	11.74	11.34	10.95	10.55	10.16	9.76	9.37	8.97
117	14.83	14.04	13.65	13.25	12.85	12.46	12.06	11.67	11.27	10.88	10.48	10.09	9.69	9.30
120	15.16	14.37	13.97	13.58	13.18	12.78	12.39	11.99	11.60	11.20	10.80	10.41	10.02	9.62

normal to severe as described by the Jewish Hospital Voice Profile (Appendix B) for girls (Table III) and boys (Table IV).

The F ratio (Table I) statistically demonstrated that the variables of degree of hoarseness, sex, and age are significantly related to the phonation of /a/ at .01 probability level with 186 degrees of freedom. It is apparent from Tables III and IV that a negative relationship exists between hoarseness and the duration of phonation of /a/. As hoarseness increases, the duration of /a/ decreases. This relationship was determined to be statistically significant at the .001 probability level, using the two-tailed t test for unrelated measures with 186 degrees of freedom. Age was shown to be a significant factor relative to length of phonation at the .001 probability level, using the t test with 186 degrees of freedom; as age increases, length of /a/ also increases. No statistically significant difference between the sexes in their abilities to phonate /a/ was found utilizing the t test with 186 degrees of freedom. However, it can be noted by comparing Tables III and IV that males consistently phonate longer than females.

The analysis of variance of the regression indicates that only 27.31 per cent of the variance between subjects' phonations of /a/ can be explained by the three variables identified in the study as degree of hoarseness, sex, and age. Unidentified variables account for 72.69 per cent of the variance.

II DISCUSSION

The purpose of this investigation was to determine if the length of phonation of /a/ in children remains the same regardless of severity of hoarseness, sex, or age. The results, as indicated in Tables III and IV, show that degree of hoarseness and age of the subject influence the duration of phonation. A statistical comparison of the information presented in Tables III and IV demonstrated no significant difference between sexes.

The negative relationship between the severity of hoarseness and duration of phonation of /a/ is not surprising. As mentioned previously, breathiness, i.e., excessive escapage of expired air during phonation, is one component of hoarseness. Thus, children with hoarse voices allow excessive air to escape through the vocal folds. Such inefficient usage of the air stream may be the result of a vocal fold structural deviancy, such as a growth, swelling, or rough edges which prevent normal approximation of the vocal folds. It might be assumed, therefore, as the severity of hoarseness increases, chances of greater vocal fold pathology increase, which likely would result in greater expenditure of air.

It also was expected that as age increases, phonation length of /a/ increases. As a child grows older and his body larger, vital lung capacity normally increases. More air, therefore, is available to sustain phonation for a longer period of time.

The lack of any statistically significant difference between the sexes in their abilities to phonate /a/ was also expected. Children

between the ages of six and ten are generally prepubescent and secondary sex characteristics, such as laryngeal growth, have not yet developed. It should be noted, however, that although it was not statistically significant, there was a consistent trend for males to phonate slightly longer than females. This is consistent with Launer (1971), who found a statistical significance in her male subjects' abilities to phonate longer than female subjects.

It should be explained that the variation of the ability to sustain /a/ was substantial. For example, one normal voiced, ten-year-old male subject phonated 17 3/4 seconds, while another normal voiced, ten-year-old male phonated 7 1/2 seconds. Several other examples could be cited. Launer (1971) also found wide variability among her subjects' abilities to phonate /a/. Results such as this would suggest that duration of phonation of /a/ is of little or no diagnostic value, even though voice experts have recommended it as a useful diagnostic procedure.

In this investigation, approximately 27 per cent of the variance between subjects' phonations of /a/ can be explained by the three variables that were identified, i.e., degree of hoarseness, sex, and age. Perhaps in future studies, lung capacity, height, and weight should not be overlooked, even though the studies by Launer (1971), Scalori in 1932, and Hulse in 1936 (Yanagihara and Koike, 1967) minimized the importance of height, weight, and vital capacity.

Another uncontrolled factor influencing phonation time may have been motivation. Each child was encouraged to do his best (instructions used for eliciting /a/ are given in Appendix C). Motivation,

however, is an illusive psychological factor which is not easily defined nor measured.

Intensity and frequency of the vocal tone also may have affected length of phonation. Van Riper and Irwin (1958) have stated,

> . . . other factors being equal, it generally requires greater expenditure of air per unit of time to produce voice of great intensity than to produce voice of moderate intensity.

The frequency of vocal fold vibration used by subjects to produce /a/ also may have affected duration. Yanagihara and Koike (1967) found that phonation time decreased significantly with a rise in pitch, e.g., from a medium to a high pitch.

Fatigue as reported by Ptacek and Sander (1963) had no effect among their adult subjects. Fatigue may have an effect on length of phonation of children, however. It would be difficult to account for this factor.

Despite the fact that only 27.31 per cent of the variance among the subjects can be explained by the controlled variables in this study, the present study provides interesting data. In a previous study reported by Launer (1971), sex was reported to be an important factor in length of phonation; in this investigation sex was not shown to be an important factor in children between the ages of six and ten.

CHAPTER V

SUMMARY AND IMPLICATIONS

I SUMMARY

Hoarseness seems to be the primary type of voice disorder occurring in school-aged children. Voice experts have suggested measurement of maximum phonation times as a clinical tool for assessing vocal function (Fairbanks, 1940; Westlake and Rutherford, 1961; Irwin, 1965; Boone, 1971). Most of the studies on duration of phonation have used adults as subjects; few investigations have involved children. An apparent need, therefore, existed to investigate duration of phonation in young children.

Accordingly, the present study was designed to measure and compare the duration of phonation of /a/ produced by children ranging in age from six to ten with normal and hoarse voices. The essential question was:

> Does the length of phonation of /a/ in children remain the same regardless of severity of hoarseness, sex, and/or age?

The results indicated: 1) The three variables of degree of hoarseness, sex, and age collectively affect duration of phonation of /a/; 2) as hoarseness increases, the duration of phonation of /a/ decreases; 3) sex is not a statistically significant factor affecting length of phonation; and 4) as age increases, phonation time also increases.

Analysis of variance showed that only 27.31 per cent of the variance between subjects' phonations of /a/ could be explained by the three variables identified in this study as degree of hoarseness, sex, and age. It was assumed that other factors affecting the variance might include lung capacity, height, weight, motivation, fatigue, intensity, and frequency of the vocal tone.

A statistical formula was presented for predicting length of phonation for children between the ages of six and ten with hoarse and normal voices, as identified by the Jewish Hospital Voice Profile (Wilson, 1971). However, because of wide variability among subjects, this formula has little or no clinical relevance for the practicing speech pathologist. Results suggest that duration of phonation of /a/ may not have the diagnostic significance accorded it by voice experts.

II IMPLICATIONS

Clinical

This study and the study by Launer (1971) demonstrated a large variance among children's ability to phonate /a/; therefore, it would seem that measuring duration of phonation in a voice disordered client may have little diagnostic value, initially. However, since duration of phonation of /a/ increases as hoarseness decreases, increasing phonation time during clinical management indicates a reduction in hoarseness, thus providing a technique for assessing progress during clinical management.

Research

The data from this study indicated the sex of children between the ages of six and ten makes no significant difference in the length of phonation of /a/. Further research is needed to determine if, at any age above ten years, sex becomes a significant factor.

In addition, it is suggested that prior to collecting further data, the importance of variables such as lung capacity, height, weight, motivation, fatigue, and intensity and frequency of the vocal tone be determined or investigated.

It also would be interesting to conduct longitudinal studies of duration of phonation of /a/ with hoarse voice-disordered subjects and with normal voiced subjects. Such an investigation would determine how length of phonation varies over time.

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APPENDIX A

VOICE SCALE BY ISSHIKI, OKAMURA, TANABE, AND MORIMOTO (1969)

dark	:___:___:___:___:___:___:___:	bright
sharp	:___:___:___:___:___:___:___:	dull
calm	:___:___:___:___:___:___:___:	excited
thick	:___:___:___:___:___:___:___:	thin
dry	:___:___:___:___:___:___:___:	wet
choked	:___:___:___:___:___:___:___:	free
sickly	:___:___:___:___:___:___:___:	lively
pessimistic	:___:___:___:___:___:___:___:	optimistic
round	:___:___:___:___:___:___:___:	pointed
smooth	:___:___:___:___:___:___:___:	rough
narrow	:___:___:___:___:___:___:___:	broad
heavy	:___:___:___:___:___:___:___:	light
cold	:___:___:___:___:___:___:___:	hot
poor	:___:___:___:___:___:___:___:	rich
soft	:___:___:___:___:___:___:___:	hard
clear	:___:___:___:___:___:___:___:	cloudy
bad	:___:___:___:___:___:___:___:	good

APPENDIX B

JEWISH HOSPITAL VOICE PROFILE

NAME_____ AGE_____ B.D._____ GRADE_____ SEX_____

How long has the problem existed? Voice Severity: 1 2 3 4 5 6 7
In what situations is the voice better or worse? Articulation Disorder:
Yes_____ No_____

Length of sustained "ah"_____

LARYNGEAL CAVITY		RESONATING CAVITY	
PITCH		NASALITY	
HIGH		HYPERNASAL	
B		C	
	+3		+4
	+2		+3
A open	-4 -3 -2 1 +2 +3 closed		+2
	-2		1
	-3		-2
LOW		HYPONASAL	

Constant_____	Rate	Intensity	Vocal Range
Variable_____	-2 1 +2	-2 1 +2	-2 1 +2
	Slow Fast	Soft Loud	Monotone Variable Pitch

Comments:_____

Examiner_____

Date_____

APPENDIX C

INSTRUCTIONS FOR ELICITING /a/

"I want to find out how long people can say /a/, and I'd like you to help me. Now I'd like you to say /a/ into this microphone like this." (Examiner models a maximum phonation of /a/.)

"Okay, now you try it."

"Good. That time you said /a/ this long." (Examiner shows subject how far the watch hand travelled around the stop watch and discusses any mistakes the child makes. The examiner reinstructs the subject after every trial until two appropriate consecutive productions of /a/ have been completed.)

"This time I'm going to record you. Ready. Go."

"Good. Do it once more."